GENERAL SYSTEM THEORY

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The Role in Scientific and Educational Integration of Unifying Principles, Conceptual Models and Laws that Run Through Levels of Nature, Applying to Diverse Systems in General, and Manifesting Themselves as Organization

The Quest for a General System Theory

Modern science is characterized by its ever-increasing specialization, necessitated by the enormous amount of data, the complexity of techniques and of theoretical structures within every field. This, however, has led to a breakdown of science as an integrated realm: The physicist, the biologist, the psychologist and the social scientist are, so to speak, encapsulated in a private universe, and it is difficult to get word from one cocoon to the other.

There is, however, another remarkable aspect. If we survey the evolution of modern science, as compared to science a few decades ago, we are impressed by the fact that similar general viewpoints and conceptions have appeared in very diverse fields. Problems of organization, of wholeness, of dynamic interaction, are urgent in modern physics, chemistry, physical chemistry, and technology. In biology now, problems of an organismic sort are everywhere encountered: it is necessary to study not only isolated parts and processes, but the essential problems are the organizing relations that result from dynamic interaction and make the behavior of parts different when studied in isolation or within the whole. The same trend is manifest in *gestalt* theory and other movements as opposed to classical psychology, as well as in modern conceptions of the social sciences. These parallel developments in the various fields are even more dramatic if we consider the fact that they are mutually independent and largely unaware of each other.

Up to recent times, the corpus of laws of nature was almost identical with theoretical physics. Few attempts to state exact laws in non-physical fields have gained universal recognition. However, the impact and the development of the biological, behavioral, and social sciences seem to make necessary an expansion of our conceptual schemes in order to allow for systems of laws in fields where application of physics is not sufficient or possible.

Such trend towards generalized theories is taking place in many fields and in a variety of ways. For example, an elaborate theory of the dynamics of biological populations, the struggle for existence and biological equilibria, has developed, starting with the pioneering work by Lotka and Volterra. The theory operates with biological notions such as individuals, species, coefficients of competition, and the like. A similar procedure is applied in quantitative economics and econometrics. The models and families of equations here applied happen to be similar to those of Lotka or, for that matter, of chemical kinetics, but the model of interacting entities and forces is at a different level. To take another example: living organisms are essentially open systems, that is, systems exchanging matter with their environment. Conventional physics and physical chemistry deal with closed systems, and only in recent years has theory been expanded to include irreversible processes, open systems, and states of non-equilibrium. If, however, we want to apply the model of open systems to, say, the phenomena of animal growth, we automatically come to a generalization of theory referring not to physical but to biological units. In other words, we are dealing with generalized systems. The same is true of the fields of cybernetics and theory of information which have gained so much interest in the past few years.

Thus, there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations or "forces" between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of

universal principles applying to systems in general.

In this way we come to postulate a new discipline, called General System Theory. Its subject matter is the formulation and derivation of those principles which are valid for "systems" in general.

(1) A first consequence of the existence of general system properties is the appearance of structural similarities or isomorphies in different fields. There are correspondences in the principles which govern the behavior of entities that are, intrinsically, widely different. This correspondence is due to the fact that they all can be considered, in certain respects, as "systems," that is, complexes of elements standing in interaction. The fact that the fields mentioned, and many others as well, are concerned with "systems," leads to a correspondence in general principles and even in special laws when the conditions correspond in the phenomena under consideration.

In fact, similar concepts, models and laws have often appeared in widely different fields, independently and based upon totally different facts. There are many instances where identical principles were discovered several times because the workers in one field were unaware that the theoretical structure required was already well developed in some other field. General System Theory will go a long way towards avoiding such unnecessary duplication of labor.

System isomorphies also appear in problems which are recalcitrant to quantitative analysis but nevertheless of great intrinsic interest. There are, for example, isomorphies between biological systems and "epiorganisms" (Gerard) like animal communities and human societies. Which principles are common to the several levels of organization and so may legitimately be transferred from one level to another, and which are specific so that transfer leads to dangerous fallacies? Can civilizations and cultures be considered as systems?

It seems, therefore, that a general theory of systems would be a useful tool providing, on the one hand, models that can be used in, and transferred to, different fields, and safeguarding, on the other hand, from vague analogies which often have marred the progress in these fields.

(2) There is, however, another and possibly more important aspect of General System Theory. To use an expression of W. Weaver, classical science was highly successful in developing the theory of unorganized or disorganized complexity which stems from statistics, the laws of chance, and, in the last resort, the second law of thermodynamics. Today our main problem is that of organized complexity. Concepts like those of organization, wholeness, directiveness, teleology, control, self-regulation, differentiation and the like are alien to conventional physics. However, they pop up everywhere in the biological, behavioral, and social sciences, and are, in fact, indispensable for dealing with living organisms or social groups. Thus, a basic problem posed to modern science is a general theory of organization. General System Theory is in principle capable of giving exact definitions for such concepts and, in suitable cases, of putting them to quantitative analysis.

(3) If we have briefly indicated what General System Theory means, it will avoid misunderstanding also to state what it is not. It is not pure mathematics or identical with the triviality that mathematics of some sort can be applied to any sort of problem; instead it poses specific problems which are far from being trivial. Further, General System Theory is not a search for vague and superficial analogies between physical, biological, and social systems. Analogies as such are of little value, since beside similarities between phenomena, dissimilarities always can be found as well. The isomorphy we have mentioned is a consequence of the fact that, in certain aspects, corresponding abstractions and conceptual models can be applied to different phenomena. It is only in view of these aspects that system laws will apply. This does not mean that physical systems, organisms and societies are all the same. In principle, it is the same situation as when the law of gravitation applies to Newton's apple, the planetary system, and the phenomenon of tide. This means that in view of some rather limited aspects a certain theoretical system, that of mechanics, holds true; it does not mean that there is a particular resemblance between apples, planets, and oceans in a great number of other aspects.

Aims of General System Theory

Summarizing, the aims of General System Theory can be indicated as follows:

(a) There is a general tendency towards integration in the various sciences, natural and social.

(b) Such integration seems to be centered in a general theory of systems.

(c) Such theory may be an important means for aiming at exact theory in the non-physical fields of science.

(d) Developing unifying principles running "vertically" through the universes of the individual sciences, this theory brings us nearer to the goal of the unity of science.

(e) This can lead to a much-needed integration in scientific education.

A remark as to the delimitation of the theory here discussed seems to be appropriate. The term and program of a General System Theory was introduced by the present author a number of years ago. It has turned out, however, that quite a large number of workers in various fields have been led to similar conclusions and ways of approach. It is suggested, therefore, to maintain this name which is now coming into general use, be it only as a conventional label.

It looks, at first, as if the definition of systems as "sets of elements standing in interaction" is so general and vague that not much can be learned from it. This, however, is not true. Systems can, for example, be defined by certain families of differential equations and if, in the usual way of mathematical reasoning,

more specified conditions are introduced, many important properties can be found of systems in general and more special cases.

This mathematical approach followed in General System Theory is not the only possible or most general one. There are a number of related modern approaches, such as information theory, cybernetics, game, decision, and net theories, stochastic models, operations research, to mention only the most important ones. However, the fact that differential equations cover extensive fields in the physical, biological, economical, and probably also the behavioral sciences, makes them a suitable access to the study of generalized systems.

I am now going to illustrate General System Theory by way of some examples.

Closed and Open Systems: Limitations of Conventional Physics

My first example is that of closed and open systems. Conventional physics deals only with closed systems, that is, systems which are considered to be isolated from their environment. Thus, physical chemistry tells us about the reactions, their rates, and the chemical equilibria eventually established in a closed vessel where a number of reactants is brought together. Thermodynamics expressly declares that its laws only apply to closed systems. In particular, the second principle of thermodynamics states that, in a closed system, a certain quantity, called entropy, must increase to a maximum, and eventually the process comes to a stop at a state of equilibrium. The second principle can be formulated in different ways, one being that entropy is a measure of probability, and so a closed system tends to a state of most probable distribution. The most probable distribution, however, of a mixture, say, of red and blue glass beads, or of molecules having different velocities, is a state of complete disorder; having separated all red beads on one hand, and all blue ones on the other, or having, in a closed space, all fast molecules, that is, a high temperature on the right side, and all slow ones, a low temperature, at the left, is a highly improbable state of affairs. So the tendency towards maximum entropy or the most probable distribution is the tendency to maximum disorder.

However, we find systems which by their very nature and definition are not closed systems. Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, building up and breaking down of components, never being, so long as it is alive, in a state of chemical and thermodynamic equilibrium but maintained in a so-called steady state which is distant from the latter. This is the very essence of that fundamental phenomenon of life which is called metabolism, the chemical processes within living cells. What now? Obviously, the conventional formulations of physics are, in principle, inapplicable to the living organism *qua* open system and steady state, and we may well suspect that many characteristics of living systems which are paradoxical in view of the laws of physics, are precisely a consequence of this fact.

It is only in recent years that an expansion of physics, in order to include open systems, has taken place. This theory has shed light on many obscure phenomena in physics and biology, and has also led to important general conclusions of which I will mention only two.

The first is the principle of equifinality. In any closed system, the final state is unequivocally determined by the initial conditions: for example, the motion in a planetary system where the positions of the planets at a time t are unequivocally determined by their positions at a time t_0. Or in a chemical equilibrium, the final concentrations of the reactants naturally depend on the initial concentrations. If either the initial conditions or the process is altered, the final state will also be changed. This is not so in open systems. Here, the same final state may be reached from different initial conditions and in different ways. This is what is called equifinality, and it has a significant meaning for the phenomena of biological regulation. Those who are familiar with the history of biology will remember that it was just equifinality that led the German biologist Driesch to embrace vitalism, that is, the doctrine that vital phenomena are inexplicable in terms of natural science. Driesch's argument was based on experiments on embryos in early development. The same final result, a normal individual of the sea urchin, can develop from a complete ovum, from each half of a divided ovum, or from the fusion product of two whole ova. The same applies to embryos of many other species, including man, where identical twins are the product of the splitting of one ovum. Equifinality, according to Driesch, contradicts the laws of physics, and can be accomplished only by a soul-like vitalistic factor which governs the processes in foresight of the goal, the normal organism to be established. It can be shown, however, that open systems, insofar as they attain a steady state, must show equifinality, so the supposed violation of physical laws disappears.

Another apparent contrast between inanimate and animate nature is what sometimes was called the violent contradiction between Lord Kelvin's degradation and Darwin's evolution, between the law of dissipation in physics and the law of evolution in biology. According to the second principle of thermodynamics, the general trend of events in physical nature is toward states of maximum disorder and levelling down of differences, with the so-called heat death of the universe as the final outlook, when all energy is degraded into evenly distributed heat of low temperature, and the world process comes to a stop. In contrast, the living world shows, in embryonic development and in evolution, a transition towards higher order, heterogeneity, and organization. But on the basis of the theory of open systems, the apparent contradiction between entropy and evolution disappears. In all irreversible processes, entropy must increase. Therefore,

the change of entropy in closed systems is always positive, order is continually destroyed. In open systems, however, we have not only production of entropy due to irreversible processes, but also import of entropy which may well be negative. This is the case in the living organism which imports complex molecules high in free energy. Thus, living systems, maintaining themselves in a steady state, can avoid the increase of entropy, and may even develop towards states of increased order and organization.

From these examples, you may guess the bearing of the theory of open systems. Among other things, it shows that many supposed violations of physical laws in living nature do not exist, or rather that they disappear with the generalization of physical theory. In a generalized version the concept of open systems can be applied to non-physical levels. Examples are its use in ecology and the evolution towards a climax formation (Whittacker), in psychology where "neurological systems" were considered as "open dynamic systems" (Krech), in philosophy where the trend toward "trans-actional" as opposed to "self-actional" and "inter-actional" viewpoints closely corresponds to the open-system model (Bentley).

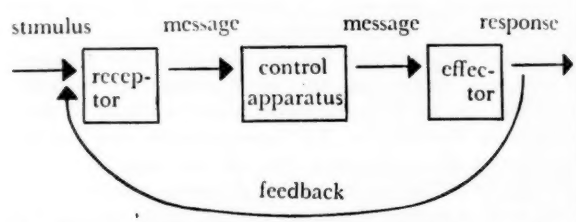
Information and Entropy

Another development which is closely connected with system theory is that of the modern theory of communication. It has often been said that energy is the currency of physics, just as economic values can be expressed in dollars or pounds. There are, however, certain fields of physics and technology where this currency is not readily acceptable. This is the case in the field of communication which, due to the development of telephones, radio, radar, calculating machines, servomechanisms and other devices, has led to the rise of a new branch of physics.

The general notion in Communication Theory is that of information. In many cases, the flow of information corresponds to a flow of energy, for example, if light waves emitted by some objects reach the eye or a photo-electric cell, elicit some reaction of the organism or some machinery, and thus convey information. However, examples can easily be given where the flow of information is opposite to the flow of energy, or where information is transmitted without a flow of energy or matter. The first is the case in a telegraph cable, where a direct current is flowing in one direction, but information, a message, can be sent in either direction by interrupting the current at one point and recording the interruption at another. For the second case, think of the photoelectric door openers as they are installed in many supermarkets: the shadow, the cutting off of light energy, informs the photocell that somebody is entering, and the door opens. So information, in general, cannot be expressed in terms of energy.

There is, however, another way to measure information, namely, in terms of decisions. Take the game of Twenty Questions, where we are supposed to find out an object by having answered questions about it by yes or no. The amount of information conveyed in one answer is a decision between two alternatives, such as animal or non-animal. With two questions, it is possible to decide for one out of four possibilities, for example, mammal — non-mammal, or flowering plant — non-flowering plant. With three answers, it is a decision out of eight, and so forth. Thus, the logarithm at the basis 2 of the possible decisions can be used as a measure of information, the unit being the so-called binary unity or bit. The information contained in two answers is $\log_2 4 = 2$ bits, of three answers, $\log_2 8 = 3$ bits, and so forth. This measure of information happens to be similar to that of entropy or rather negative entropy, since entropy also is defined as a logarithm of probability. But entropy, as we have already heard, is a measure of disorder; hence negative entropy or information is a measure of order or of organization since the latter, compared to distribution at random, is an improbable state. In this way Communication Theory comes close to the theory of open systems, which may increase in order and organization, or show negative entropy. But negative entropy can be considered a measure of decisions, taken out of equally probable ones, a measure of improbability or information.

Another central concept of Communication Theory is that of feedback. A simple scheme for feedback is the following. In the classical case of stimulus-response, a stimulus affects a receptor;



the message of the receptor is transmitted to some controlling apparatus, and from this to an effector which gives the response. In feedback, the result of the effector's activity is monitored back to the receptor so that the system is self-regulating.

Feedback arrangements are used in modern technology to a wide extent for the stabilization of a certain action, as in thermostats or in radio receivers; or for the direction of actions towards a goal where the aberration from that goal is fed back, as information, till the goal or target is reached. This is the case in self-propelled missiles which seek their target, anti-aircraft fire control systems, ship-steering systems, and other so-called servomechanisms.

There is a large number of biological phenomena which correspond to the feedback scheme. First, there are the phenomena of so-called homeostasis, or maintenance of balance in the living organism, the prototype of which is thermoregulation in warm-blooded animals. Cooling of the blood stimulates certain centers in the brain which "turn on" heat producing

mechanisms of the body, and the body temperature is monitored back to the center so that temperature is maintained at a constant level. Similar homeostatic mechanisms exist in the body for maintaining the constancy of a great number of physico-chemical variables. Furthermore, feedback systems comparable to the servomechanisms of technology exist in the animal and human body for the regulation of actions. If we want to pick up a pencil, report is made to the central nervous system of the amount of which we have failed the pencil in the first instance; this information then is fed back to the central nervous system so that the motion is controlled till it reaches its aim.

So a great variety of systems in technology and in living nature follow the feedback scheme, and it is well known that a new discipline, called Cybernetics, was introduced by Norbert Weiner to deal with these phenomena. The theory tries to show that mechanisms of a feedback nature are at the basis of teleological or purposeful behavior in man-made machines as well as in living organisms, and in social systems.

It should be borne in mind, however, that the feedback scheme is of a rather special nature. It presupposes structural arrangements of the type mentioned. There are, however, many regulations in the living organism which are of essentially different nature, namely, those where the order is effectuated by a dynamic interplay of processes. Remember the classical example of embryonic regulation where the whole is re-established from the parts in an equifinal process. It can be shown that the *primary* regulations in organic systems, that is, those which are most fundamental and primitive in embryonic development as well as in evolution, are of such nature of dynamic interaction. They are based upon the fact that the living organism is an open system, maintaining itself in, or approaching a steady state. Superimposed are those regulations which we may call *secondary,* and which are controlled by fixed arrangements, especially of the feedback type. This state of affairs is a consequence of a general principle of organization which may be called progressive mechanization. At first, systems—biological, neurological, psychological or social—are governed by dynamic interaction of their components; later on, fixed arrangements and conditions of constraint are established which render the system and its parts more efficient, but also gradually diminish and eventually abolish its equipotentiality. Thus, dynamics is the broader aspect, since we can always arrive from general system laws to machine-like function by introducing suitable conditions of constraint, but the opposite way is not practicable.

Causality and Teleology

Another point I would like to make is the change the scientific world-picture has undergone in the past few decades. In the world view called mechanistic, born of classical physics of the 19th century, the aimless play of the atoms, governed by the inexorable laws of mechanical causality, produced all phenomena in the world, inanimate, living, and mental. No room was left for any directiveness, order, or *telos.* The world of the organisms appeared a mere product of chance, accumulated by the senseless play of mutation at random and selection; the mental world as a curious and rather inconsequential epiphenomenon of material events.

The only goal of science appeared to be the analytical, that is, the splitting-up of reality into ever smaller units and the isolation of individual causal trains. Thus, physical reality was split up into mass points or atoms, the living organism into cells, behavior into reflexes, perception into punctual sensations, and so forth. Correspondingly, causality was essentially one-way: one sun attracts just one planet, one gene in the fertilized ovum produces such and such inherited character, one sort of bacterium produces this or that disease, mental elements are lined up, like the beads in a string of pearls, by the law of association. Remember Kant's famous table of the categories which attempts to systematize the fundamental notions of classical science: it is symptomatic that the notion of interaction and of organization were only space-fillers or did not appear at all.

Now we may state as characteristic of modern science that this scheme of isolable units acting in one-way causality has proved to be insufficient. Hence the appearance, in all fields of science, of notions like wholeness, holistic, organismic, *gestalt* and so forth which all signify that in the last resort, we must think in terms of systems of elements in mutual interaction.

Similarly, notions of teleology and directiveness appeared to be outside the scope of science and the playground of mysterious, super-natural or anthropomorphic agencies; or else, a pseudoproblem, intrinsically alien to science, and merely a misplaced projection of the observer's mind into a nature governed by purposeless laws. Nevertheless, these aspects exist, and you cannot conceive of a living organism, not to speak of behavior and human society, without taking into account what variously and rather loosely is called adaptiveness, purposiveness, goal-seeking and the like.

It is characteristic of the present view that these aspects are taken seriously as a legitimate problem for science; moreover, we can well indicate models showing such behavior.

Two such models we have already mentioned. One is equifinality, the tendency towards a characteristic final state from different initial states and in different ways, based upon dynamic interaction in an open system attaining a steady state; the second, feedback, the homeostatic maintenance of a characteristic state or the seeking of a goal, based upon circular causal chains and mechanisms monitoring back information on deviations from the state to be attained or the goal to be reached. A third model for adaptive behavior, a *Design for a Brain,* was developed by Ashby, who incidentally starts with the same mathematical definitions and equations for a general system as were used by the present author. Both writers have

developed their systems independently and, following different lines of interest, have arrived at different theorems and conclusions. Ashby's model for adaptiveness is, roughly, that of step functions defining a system, that is, functions which, after a certain critical value is overstepped, jump into a new family of differential equations. This means that, having passed a critical state, the system starts off in a new way of behavior. Thus, by means of step functions, the system shows adaptive behavior by what the biologist would call trial and error: it tries different ways and means, and eventually settles down in a field where it does not come any more in conflict with critical values of the environment. Such a system adapting itself by trial and error was actually constructed by Ashby as an electromagnetic machine, called the homeostat.

I am not going to discuss the merits and shortcomings of these models of teleological or directed behavior. What should be stressed, however, is the fact that teleological behavior directed towards a characteristic final state or goal is not something off limits of natural science and an anthropomorphic misconception of processes which, in themselves, are undirected and accidental. Rather it is a form of behavior which can well be defined in scientific terms and for which the necessary conditions and possible mechanisms can be indicated.

What Is Organization?

Similar considerations apply to the concept of organization. Organization also was alien to the mechanistic world. The problem did not appear in classical physics, mechanics, electrodynamics and so forth. Even more, the second principle indicated destruction of order as the general direction of events. It is true that this is different in modern physics. An atom, a crystal, or a molecule are organizations, as Whitehead never failed to emphasize. In biology, organisms, by definition, are organized things. But although we have an enormous amount of data on biological organization, from biochemistry to cytology, to histology and anatomy, we do not have a real theory of biological organization, that is, a conceptual system which permits explanation of the empirical facts.

Characteristic of organization, that of a living organism or a society, are notions like those of wholeness, growth, differentiation, hierarchical order, dominance, control, competition, and so forth. Such notions do not appear in conventional physics. System theory is well capable of dealing with these matters. It is possible to define such notions within the mathematical model of a system; moreover, in some respects, detailed theories can be developed which deduce, from general assumptions, the possible special cases. A good example is the theory of biological equilibria, cyclic fluctuations, and so forth, as initiated by Lotka, Volterra, Gause and others. It will certainly be found that Volterra's biological theory and the theory of quantitative economics are isomorphic in many respects.

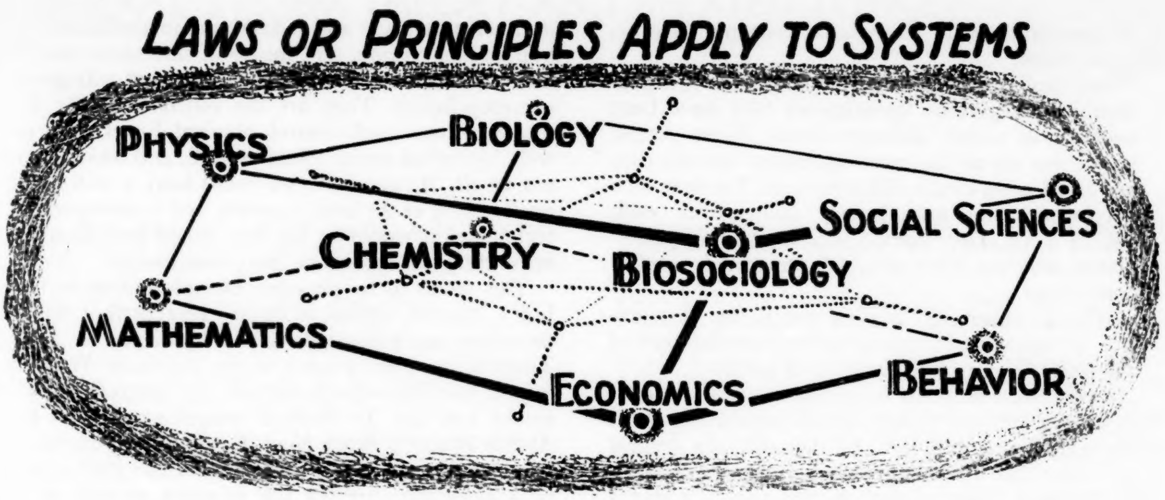
There are, however, many aspects of organizations which do not easily lend themselves to quantitative interpretation. This difficulty is not unknown in natural science. Thus, the theory of biological equilibria or that of natural selection are highly developed fields of mathematical biology, and nobody doubts that these theories are legitimate, essentially correct, and an important part of the theory of evolution and of ecology. It is hard, however, to apply them in the field because the parameters chosen, such as selective value, rate of destruction and generation and the like cannot easily be determined. So we have to content ourselves with a qualitative argument which, however, may lead to interesting consequences.

As an example of the application of General System Theory to human society, I would like to quote a recent book by Boulding, entitled *The Organizational Revolution*. Boulding starts with a general model of organization and states what he calls Iron Laws holding good for any organization. Such Iron Laws are, for example, the Malthusian law that the increase of a population is greater than that of its resources. Then there is a law of the optimum size of organizations: the larger an organization grows, the longer is the way of communication and this, depending on the particular nature of the organization, acts as a limiting factor and does not allow an organization to grow beyond a certain critical size. According to the law of instability, many organizations are not in a stable equilibrium but show cyclic fluctuations which result from the interaction of subsystems. This, incidentally, could probably be treated in terms of the Volterra theory, Volterra's so-called first law being that of periodic cycles. The important law of oligopoly states that, if there are competing organizations, the instability of their relations and hence the danger of friction and conflicts increase with the decrease of the number of those organizations. Thus, so long as they are relatively small and numerous, they muddle through in some way of coexistence. But if only a few or a competing pair is left, as is the case with the colossal political blocks at the present day, conflicts become devastating to the point of complete mutual destruction. The number of such general theorems for organization can easily be enlarged. They are well capable of being developed in an exact way, as it actually was done for certain aspects.

General System Theory and the Unity of Science

Let me close these remarks with a few words about the general implications of interdisciplinary theory.

The integrative function of General System Theory can perhaps be summarized as follows. So far, the unification of science has been seen in the reduction of all sciences to physics, in the final resolution of all phenomena into physical events. From our point of view, unity of science gains a more realistic aspect. A unitary conception of the world may be based, not upon the possibly futile and certainly far-fetched hope finally to reduce all levels of reality to the level of physics, but rather on the isomorphy of laws in different fields. Speaking in what has been called the



"formal" mode, that is, looking at the conceptual constructs of science, this means structural uniformities of the schemes we are applying. Speaking in "material" language, it means that the world, that is, the total of observable phenomena, shows structural uniformities, manifesting themselves by isomorphic traces of order in its different levels or realms.

We come, then, to a conception which in contrast to reductionism, we may call perspectivism. We cannot reduce the biological, behavioral, and social levels to the lowest level, that of the constructs and laws of physics. We can, however, find constructs and possibly laws within the individual levels. The world is, as Aldous Huxley once put it, like a Neapolitan ice cake where the levels, the physical, the biological, the social and the moral universe, represent the chocolate, strawberry, and vanilla layers. We cannot reduce strawberry to chocolate—the most we can say is that possibly in the last resort, all is vanilla, all mind or spirit. The unifying principle is that we find organization on all levels. The mechanistic world view, taking the play of physical particles for ultimate reality, found its expression in a civilization glorifying physical technology which eventually has led to the catastrophes of our time. Possibly the model of the world as a great organization can help to re-enforce the sense of reverence for the living which we have almost lost in the last sanguinary decades of human history.

General System Theory in Education:
The Production of Scientific Generalists

After this necessarily sketchy outline of the meaning and aims of General System Theory, let me try to answer the question what it may contribute to integrative education. In order not to appear partisan, I give a few quotations from authors who were not themselves engaged in the development of General System Theory.

A few years ago, a paper, entitled "The Education of Scientific Generalists," was published by a group of scientists comprising the engineer Bode, the sociologist Mosteller, the mathematician Tukey, and the biologist Winsor. The authors emphasize the "need for a simpler, more unified approach to scientific problems." They write:

> "We often hear that 'one man can no longer cover a broad enough field' and that 'there is too much narrow specialization'. . . We need a simpler, more unified approach to scientific problems, we need men who practice science—not a particular science, in a word, we need scientific generalists."

The authors then make clear how and why generalists are needed in various fields such as physical chemistry, biophysics, the application of chemistry, physics, and mathematics to medicine, and they continue:

> "Any research group needs a university or a foundation, or an industrial group . . . .In an engineering group, the generalist would naturally be concerned with system problems. These problems arise whenever parts are made into a balanced whole."

In a symposium of the Foundation for Integrated Education, Professor Mather discussed "Integrative Studies for General Education." He states:

> "One of the criticisms of general education is based upon the fact that it may easily degenerate into the mere presentation of information picked up in as many fields of enquiry as there is time to survey during a semester or a year . . . If you were to overhear several senior students talking, you might hear one of them say 'our professors have stuffed us full, but what does it all mean?' . . . More important is the search for basic concepts and underlying principles that may be valid throughout the entire body of knowledge."

In answer to what these basic concepts may be, Mather states:

"Very similar general concepts have been independently developed by investigators who have been working in widely different fields. These correspondences are all the more significant because they are based upon totally different facts. The men who developed them were largely unaware of each other's work. They started with conflicting philosophies and yet have reached remarkably similar conclusions . . .

"Thus conceived," Mather concludes, "Integrative studies would prove to be an essential part of the quest for an understanding of reality."

No comments seem to be necessary. Conventional education in physics, biology, psychology or the social sciences treats them as separate domains, the general trend being that increasingly smaller sub-domains become separate sciences, and this process is repeated to the point where each specialty becomes a triflingly small field, unconnected with the rest. In contrast, the educational demands of training "Scientific Generalists" and of developing interdisciplinary "basic principles" are precisely those General System Theory tries to fill. They are not a mere program or a pious wish since, as we have tried to show, such theoretical structure is already in the process of development. In this sense, General System Theory seems to be an important headway towards interdisciplinary synthesis and integrated education.

Science and Society

However, if we speak of education, we do not solely mean scientific values, that is, communication and integration of facts. We also mean ethical values, contributing to the development of personality. Is there something to be gained from the viewpoints we have discussed? This leads to the fundamental problem of the value of science in general and the behavioral and social sciences in particular.

An argument about the value of science and the impact of its gradual development upon society and the welfare of mankind would run something like this. Our knowledge of the laws of physics is excellent, and consequently our technological control of inanimate nature almost unlimited. Our knowledge of biological laws is not so far advanced, but sufficient to allow for a good amount of biological technology in modern medicine and applied biology. It has extended the span of human life far beyond the limits alloted to a human being in earlier centuries or even decades. The application of the modern methods of scientific agriculture, husbandry, and so forth, would well suffice to sustain a human population far surpassing the present one of our planet. What is lacking, however, is the knowledge of the laws of human society, and consequently a sociological technology. So the achievements of physics are put to use for ever more efficient instruments of destruction; we have famines in vast parts of the world while harvests rot or are destroyed in other parts; war and indiscriminate annihilation of human life, culture, and means of sustenance are the only way out of uncontrolled fertility and consequent over-population. They are the outcome of the fact that we know and control physical forces only too well, biological forces tolerably well, and social forces not at all. If, therefore, we could have a well-developed science of the human society and a corresponding technology it would be the way out of the chaos and impending destruction of our present world.

This seems to be plausible enough and is, in fact, but a modern version of Plato's precept that only if the rulers are philosophers, will humanity be saved. There is, however, a catch in the argument. We have quite a fair idea what a scientifically controlled world would look like. In the best case, it would look like Aldous Huxley's *Brave New World,* and in the worst, like Orwell's *1984.* It is an empirical fact that scientific achievements are put just as much, or even more, to destructive as constructive use. The science of human behavior and society is not exempt from this fate. In fact, it is perhaps the greatest danger of the systems of modern totalitarianism that they are so alarmingly up to date not only in physical and biological, but also in psychological technology. The methods of mass suggestion, of the release of the instincts of the human beast, of reflex conditioning and thought control are developed to highest efficiency, and just because modern totalitarianism is so terrifically scientific, it makes the absolutism of former periods appear a dilettantic and comparatively harmless makeshift. Scientific control of society is no highway to Utopia.

The Ultimate Precept: Man as the Individual

We may, however, conceive of a scientific understanding of human society and its laws in a somewhat different and more modest way. Such knowledge can teach us, not only what human behavior and society have in common with other organizations, but also what is their uniqueness. Here the main tenet will be: man is not only a political animal, he is, before and above all, an individual. The real values of humanity are not those which it shares with biological entities, the function of an organism or a community of animals, but those which stem from the individual mind. Human society is not a community of ants or termites, governed by inherited instinct and controlled by the laws of the superordinate whole; it is based upon the achievements of the individual, and is doomed if the individual is made a mere cog in the social machine. This, I believe, is the ultimate precept a theory of organization can give: not a manual for dictators of any denomination more efficiently to subjugate human beings by the scientific application of Iron Laws, but a warning that the Leviathan of organization must not swallow the individual without sealing its own inevitable doom.

GENERAL SYSTEM THEORY AND RELATED TOPICS:

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SOCIAL ORDER*

Lawrence K. Frank

The Challenge of Science and Its Impact on Society

Man has often been called the social animal, but for ages he has been struggling to understand his society and how it operates. Since there are so many conflicting views, both historical and modern, about the nature and operation of a social order, it may be helpful to look at human life in a deeper time perspective.

All over the world each group of people lives in a social order which has endured for centuries. Each of these social orders may be looked upon as a design for living which that group has maintained from generation to generation, relying upon the varied and sometimes highly complicated rituals and symbols, institutions, and patterns for conducting interpersonal and group relations.

This diversity of social orders cannot be explained by any simple theory of adaptation to the environment. While of necessity people have had to learn how to exploit the environment for food, shelter and protection, and have developed a variety of tools and techniques which enabled them to survive, there is no simple correspondence between their social order and the way they make a living and utilize the environment. Often they have ignored or rejected a desirable foodstuff or have learned to use something which would be poisonous, like the manioc, unless it were elaborately prepared. As the old saying goes, it was a courageous man who ate the first oyster!

If we reflect upon this situation, we realize how amazing and complicated are these social orders. Thus we may say that all over the world the basic processes of nature, which we like to call physical, chemical and biological, are essentially alike, exhibiting the orderliness, the regularity, and the sequential relations that have been revealed by scientific research. Likewise, we recognize that despite differences in size, shape and skin color, and possibly some other differences in physiological functioning, people are all human beings, belonging to the same Genus Homo. What is remarkable is that each group of people, with the same or similar human nature and facing the same natural world, nevertheless has seen that world differently and has developed a way of life which is more or less unique. Each social order is organized upon some plan or relationship, usually kingship, chieftain, priest-ruler, oligarchy, gerontocracy, with class, caste, clan, patriarchal or matriarchal authority, etc.

It is true, of course, that geographical environment differs widely and is reflected in the whole way of life of any group, but nevertheless, what and how its members live, their interpretation of the world and of social order, are not biologically determined, but are culturally patterned.

One clue to the understanding of this unique human situation is this: Unlike other organisms such as fish, reptiles, birds, or predatory, parasitic, symbiotic or insect castes, man did not adjust to the geographical environment by bodily specialization and differentiation in order to survive. Instead of following this path which in all other species has led to fixity and the end of the evolutionary road, man remained flexible and plastic. He utilized ideas and tools with which to create a human way of life in a symbolic, cultural world. This was possible because man has the largest uncommitted area of the nervous system, in the sense of being the least controlled by inherited or so-called instinctive patterns, so that he can learn and, more importantly, he can *unlearn*. Also, man has the most plastic organism, capable of a wide variety of transformations of his basic bodily functions into goal-seeking, purposive striving for deferred and symbolic fulfillment. Accordingly, man has everywhere spurned the purely biological mode of survival. Nowhere do we find him, even among the most primitive peoples, living on the basis of physiological functioning and naive impulsive behavior.

There are many ways of interpreting the beginnings of human social living, and in all probability we will never be able to discover just how this took place. One possible explanation can be put in this way: In his earliest days, man began to perceive the world in terms of some meaningful significance which he could impute to it. That is to say, instead of reacting naively to the environment as a series of signals evoking basic mammalian behavior, he viewed the world as presenting a variety of signs to which he could respond with purposive, goal-seeking conduct oriented to deferred and often symbolic fulfillments. We can only speculate upon how this developed, but it seems

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probable that quite early in his career, man began to develop what we call concepts, that is, patterned perceptions of the world which enabled him to "find" or imput a certain amount of order and regularity in the flux of experience. To put it another way, we may say that concepts developed as templates which man could apply to events and situations and so deal with them *as if* they were what he assumed and expected them to be and do. He invested the world with these meanings and viewed it in these relationships. Thus it appears that a crucial step in the development of human living was the creation of a body of concepts or assumptions which enabled man to organize life experiences and to give meaning and significance to events. With these concepts or ideas he could increasingly deal with the world through purposive, goal-seeking activities, including the use of tools and techniques. Every group of people has faced, from its earliest days, a number of persistent life tasks or problems. Thus, in order to survive, man has had to find ways of relating himself to his environment for obtaining food, shelter and protection, and other "creature comforts." Likewise, to live in a group and benefit from the division of labor and shared responsibilities, as between the two sexes, man had to establish some kind of social order or organized ways of living together and conducting his varied human relations. And, finally, if man were to maintain such a social order, he had to develop some way of educating and training the young, transforming the human organism into a human personality who could live in a social order and maintain a symbolic world while carrying on all his essential life activities.

As we reflect on these challenging life tasks, we will see that each of them is closely related to, if not implied by, the others, and that all of them call for some kind of concepts or assumptions about nature and human nature which will orient and guide human living in carrying on life tasks.

While there are many different ways of formulating these concepts, one statement of them offers a fruitful approach to an understanding of social order, indicating the relation of social order to whatever science, philosophy, religion, or other beliefs man holds about the universe. Accordingly, we may say that gradually, and probably very slowly, each group evolved a set of basic beliefs or assumptions in which they expressed their conception of the universe and of man, as follows:

1. The nature of the universe—how it was created, how it is operated, by what authority, power or processes, and how events occur in such a universe.
2. Man's place in that universe—his origin and relation to the powers and authority which are believed to rule the world and whether he is a part of nature or outside nature.
3. A conception of social order—the kind of relationships which are necessary and desirable for social order, and the sanctions for those social requirements and prescriptions.
4. A conception of human nature and conduct—man's image of himself and what must be done to and for the child so that he will be able to live in this symbolic cultural world.

It is not suggested that these formulations emerged full blown and definitely stated. Probably they came only long after people had begun to act in these terms and to express these assumptions in their earliest modes of communication, such as the plastic and graphic arts, music, dance, rituals, fables and parables, and in figures of speech such as metaphors and similes. Here it may be appropriate to point out that the basic forms of communication in most cultures are these analogical communications which preceded the more logical and digital processes as they have been developed in science, logic and mathematics.

There are a number of comments that may be made upon these four basic conceptions which we should bear in mind as we explore further the meaning of social order. One point is that these four conceptions are interrelated and inter-dependent in the sense that each one of them implies the other three. For example, the conception of human nature and man's image of himself is, at least initially, a correlative of the conception of the nature of the universe, and of man's place therein, either within or outside of nature. Likewise, the conception of social order is derived from beliefs about the nature of the universe and about human nature and finds its basic sanctions in those two conceptions, as shown by the close relation of church and state in some social orders, divine right of kings, the oath of office, etc.

Thus it would appear that from the earliest days man's efforts to establish and maintain a social order have been guided by his beliefs about the universe, man's place in that universe, and assumptions about human nature. While it may seem absurd to some to say that these earliest beliefs and aspirations toward social order were predicated upon scientific conceptions of nature, nevertheless it may be said that man's first efforts to understand the universe, however crude and illogical they may seem to us, did express the curiosity and the kind of reflective thinking which over the ages has produced disciplined inquiry and thinking and a formulation of ever more penetrating questions that we now call the scientific enterprise. From this viewpoint, Genesis is a scientific statement of major significance which offered an internally consistent and coherent set of beliefs and assumptions on each of the four basic questions stated earlier. It has served, until recently, to guide western culture.

Another aspect of this early development which seems to warrant further consideration is that these fundamental conceptions served as guides or directives in focussing and establishing man's efforts to meet the persistent tasks of life, not necessarily in terms of what was simplest, easiest and most immediately productive. Indeed, every culture shows amazing complexities, with often self-defeating beliefs and practices. But each culture gave rise to man's aspirations, what he hoped to do, to be, to attain, and so in

many ways these conceptions operated to make life more difficult and complicated. Actions guided by these basic conceptions involved a wide variety of often complicated rituals and ceremonies. Sometimes these have become so elaborate as to handicap a people's essential activities. Thus W. H. Rivers reported how canoe building among an island people died out because each step in the fabrication of a canoe was ritualized so that it was unsafe to omit part of these elaborate ceremonies. Canoe building became a dangerous trade and was given up.

Indeed, we can scarcely overemphasize this essential, if not unique, characteristic of human living in all cultures, from the more primitive to the so-called higher civilizations; namely, the effort, the striving, the continual endeavor to make the world and man fit into man's beliefs and expectations. In other words, human living is essentially an aspiration, and every culture may be regarded as that which is sought and only partially attained, but nevertheless continues to be the focus of man's endeavors.

Still another aspect of this situation needs to be recognized and emphasized, especially today, when we have so many separate scientific disciplines which fractionate the world into their separate categories of events. Thus we may say that human living, while implicated in a variety of different activities and relations, and employing an extraordinary diversity of practices, rituals and symbols, is necessarily a unified whole because each member of a social group is actively participating in all of these activities and must by some process or other reconcile what he does and why he does it. Here we get some clue to the process of "rationalization" which we now recognize as the way all of us invoke a variety of "good" reasons to explain and justify whatever we do—reasons which are often utterly irrelevant but serve largely to make what we do seem reasonable, consistent and socially acceptable.

After these excursions into some of the implications of this viewpoint, we can return to a further discussion of the meaning of social order and how each group, in accordance with its basic beliefs, transforms the young human organism into a participating member of social order, capable of living in the symbolic cultural world as defined by its traditions. We are limited by space to only a few of the more significant aspects, and shall try to show how various established conceptions of social order are now being critically reviewed and replaced with new conceptions.

As indicated earlier, the young human organism is born with all its needed organic and functional capacities. Almost immediately the parents begin to channel, pattern and transform these physiological processes into whatever their traditions prescribe as appropriate. Thus the baby's internal environment and functional processes are all regulated: His hunger is transformed into patterned appetite for the kinds of foods eaten at those intervals which his parents believe to be necessary or desirable. Likewise, his eliminations become governed by considerations of the appointed time, place and vessels proper for such operations. His sleep is regulated, and even his breathing is channeled and transformed into patterned speech for human communication. All of his functioning, including sensory awareness, becomes more or less patterned and governed by the external situation and requirements, to which his physiological processes become more or less responsive. The baby therefore ceases to be primarily and exclusively an organism, and begins increasingly to be a human person capable of meeting the sometimes onerous demands and restrictions upon his naive functioning.

When the baby begins to move about and explore the world, he meets with the many repeated "don'ts" —prohibitions upon his impulsive behavior which he must learn to respect. Sooner or later the child is required to transform these parental prohibitions into self-administered inhibitions. The parents, as agents of culture, define the world for the child in terms of what he may, must, and must not do, so that the child learns to perceive the world as untouchable, and live in it as it has been defined for him. This learning also includes the performance of the many required activities we call manners, etiquette, the early performance of the masculine or feminine roles, etc.

These childish experiences have a profound social significance. Indeed we may say that a social order depends in large degree upon the effectiveness of these early lessons in observing the inviolability of things, animals, places and persons. Man is the only organism having what we call private property or integrity of the person. It is a human social invention to make every member of the group the guardian and protector of the property and person of all others, not just his own. Indeed, every social order may be viewed as largely the product of various social inventions, such as money, legal procedures, property rights, political practices, religious and artistic performance.

This is what these early lessons in observing inviolability involve. The child learns prescribed patterns of conduct: first, to refrain from taking or hitting, later, to use the socially sanctioned practices, with all the essential rituals and symbols involved in barter, buying and selling, contracts and employment, courtship and marriage, and settling disputes. In this way he becomes an active upholder of the social order. This is a circular, reciprocal process, a transaction, not the cause and effect or stimulus and response of linear relations.

But we must not forget also that all the multitudinous relations and transactions between individuals and among members of a group become possible only because the human child has learned language as one of the modes of communcation with others, involving not only the use of verbal and written symbols, but also the capacity to recognize and respond to messages in ways that are considered appropriate. Thus we may consider economic, legal, political and social patterns, rituals and symbols as specialized modes of communication between persons and groups.

Recently it has been pointed out that in learning a

language a child not only develops a mode of communication and of expression, but also is inducted into the conceptual framework of his culture. That is, every language, by its very structure and organization, its grammar as well as its various inflections and so-called parts of speech, is an expression of the way in which that culture conceives the world and how it operates. Thus there are profound differences in the way the Indo-European languages, such as English, function as a frame of reference and as a mode of communication from the languages of the Hopi Indians or Wintu, the Trobrianders or the Balinese. In these other cultures, the language implies a very different conception of events from our linear cause and effect pattern, and in and through those languages the people relate themselves to the world and to others in quite different patterns. Accordingly, we cannot ignore the immense significance of language in the maintenance of a social order and the expression in that language of the basic assumption of a people about the nature of the universe and the other conceptions we have been discussing.

This leads us to the next point in the process of inducting the child into the social and cultural world of his parents. We see him learning to perceive the world in terms of the conceptions and assumptions of his culture. We might say that the religion and philosophy, the art, mythology and folklore, and the science or prototype of science, are incorporated into the child's basic frame of reference which he develops quite early in life in what may be called the "why-because" stage. Here, as we know, the child continually asks why, and parents and other adults reply "because . . ." giving him their version of these basic assumptions. Thereafter whatever the child experiences will be perceived and understood in terms of these conceptions, especially in the child's attempts at communication, as well as in his inner speech, "that continual talking to himself in which we all engage." Thus he is inducted into the traditional symbolic world of his parents and teachers.

It must be emphasized that in all the child's activities he will be guided by this conceptual framework of beliefs and assumptions and by his aspirations. While he may rarely or never recognize or formulate it in these terms, nevertheless he is, as a young adult, actively engaged in maintaining social order by whatever he does and how he refrains from doing what is prohibited. At the same time since all of his activities are oriented to and also responsive to others in these prescribed activities, he is governed by the very social order which he is helping to maintain.

Here we see how the long accepted Newtonian conception of social order, as a series of large scale superhuman mechanisms or systems located somewhere out in space and operated by large forces acting at a distance, has become less credible. Under this conception, we have thought of social order as something existing in its own right, so to speak, to which the individual had to adjust, and the primary emphasis has been upon obedience to the law and performance of the duties and responsibilities that each individual must sustain. Our major concepts of the relation of social order to the individual have been those of Rousseau and Hobbes, and the legal doctrine of rights, titles, interests and obligations enforced by the state.

This has been a very useful model and has fostered a variety of studies by economists, political scientists, sociologists and lawyers. We are realizing today, however, that this conception of social order is largely a figure of speech, since there is no such economic, political or social mechanism or force. Rather, what we find is that the purposive striving of large numbers of individuals channeled into the prescribed political, social and legal rituals and symbolic performances, and the responses to those strivings on the part of other individuals in the group, constitute what we have long called a "force."

What is perhaps equally important is the realization that the individual member of a group is not a passive entity being moved around by these so-called forces or the historic process. He is an active agent of social order who, whether he knows it or not, bears an immediate personal responsibility for that social order. Indeed, we may go further and say that the maintenance of a free social order depends upon the development of a high standard of individual personal ethics, as contrasted with the totalitarian societies which pose no ethical problems for their members but demand submissive obedience to authority. Moreover, we may say that one of the crucial problems of today is how to develop personalities who can bear the burdens of freedom in the sense of being self-disciplined, self-directing personalities who can and will help to maintain their social order, not as a static, fixed and unchanging entity, but rather as a dynamic circular process in which every individual is involved in striving for our enduring goal values. This again poses the question of the relation of social order to the individual, a question which we are facing in many forms but do not yet recognize as a basic problem of the contemporary world, as shown by the totalitarian, fascist and other authoritarian regimes.

Because we have had these various conceptions of social order as superhuman entity or mechanism or an authoritarian regime to which individuals must submit, we have not recognized clearly this immensely significant role of the individual, nor realized that the individual's conduct and his relations with others are largely expressive of his image of himself. Thus while each individual must use all the permitted and prescribed rituals and symbols, along with others, *how* he uses these and for what goals or purposes, good or evil, is an expression of his individual personality and, more especially, of his image of himself.

Today in the social sciences we are in a situation similar to that described by Eddington, the British astronomer, who some years ago remarked, "Physics is classical on Mondays, Wednesdays, and Fridays, and quantum on Tuesdays, Thursdays, and Saturdays." He was then referring to the unresolved con-

flict between the classical conception of particle physics and the newly formulated conceptions of quantum physics, relativity, and field theory. In much the same way, we can say that our classic social sciences, economics, political science, sociology and law are still largely committed to the older Newtonian conceptions of social order and a rational human nature, while psychiatry, clinical psychology and increasingly anthropology and social psychology are operating with conceptions of individual personality development and expression which are at variance with the older assumptions of human nature and conduct implied, if not stated, in the classical social sciences.

As we realize how man historically has established his social order, largely in terms of his basic beliefs and assumptions about the universe, and remember how we Western people have from time to time altered, and sometimes drastically revised, our conceptions of social order when we have had new concepts in scientific thinking — for example the impact of Newtonian physics upon social studies and social order as interpreted by John Locke, David Hume and their successors — then we may recognize how the new scientific thinking of today will sooner or later bring about changes in our social sciences and all our thinking about social order. This is the immense task facing social science today which most social scientists are ignoring or rejecting.

Already it seems clear that a conception of social order, in terms of a field which is created and maintained by individual members of the social order who are in turn responsive to that field which they have helped to establish, offers possibilities of greater understanding of the individual personality who is the sole active agent of all social operations. Here we again may invoke the idea of a transactional process as offering an approach to these circular reciprocal relations. Also we may cite the doctrine of complementarity as a way of stating the recurrent regularities of these socially patterned activities and also emphasizing the idiosyncratic, idiomatic individual whose goal seeking activities and strivings are the source of all social dynamics (not forces).

These new social formulations may be of incalculable significance in helping us to maintain the ideal of a free society and to work more effectively for its attainment, because they will clarify the role of the autonomous free individual personality and thereby strengthen us against the many threats of insidious propaganda and authoritarian totalitarianism which de-personalize the individual. Through the new conceptions and dynamic patterns of thinking now being developed, especially in the physical sciences, we are being offered new tools of thought by which to cope anew with the persistent life tasks and problems of social order. This gives us an opportunity to pay our debt to the past by attempting to do for today what the great figures of the past did for their time.

Progress in this direction depends in large measure upon our ability to develop an integrated, internally consistent, conceptual framework wherein our beliefs and assumptions about the universe can provide much needed support for our thinking about human nature and social order and, in turn, our concept of human nature, of culture, of social order will be found consistent with what we are now discovering about the universe. This is the major task we face today as we endeavor to reorient our social order and renew our culture.*

*Cf. *Nature and Human Nature:* Man's New Image of Himself, by L. K. Frank, Rutgers University Press, 1951, especially chapters on Cultural, Social Environments, and Private World of the Individual Personality. See also *Society as the Patient,* Essays on Science and Culture and What is Social Order, Rutgers University Press, 1948.

Other books of interest:

Uses of the Past, by Herbert J. Muller, Mentor Edition
Essay on Man, by Ernst A. Cassirer, Doubleday Anchor Book
Man Makes Himself, by V. Gordon Childe, Mentor Edition
Patterns of Culture, by Ruth Benedict, Mentor Edition

The design by A. J. Gouffe which appears on the cover represents the meaning of the Greek words lettered over it, *panta rei,* "the stream of all things flowing forth," or, as a modern would put it, emergent evolution. At the top of the drawing appear, in space, the swirling macrocosm and suggested geometry for a microcosm; out of the dark heart of substance at the center arises the cornucopia of living nature, the stream of evolution unfolding from the continuum and projecting the present, the eternal now. The light of the nebula and of the quanta above shines out again below, not only representing man's achievements as the result of biological unfoldment, but suggesting also that man, through those of his ideas which are true to nature, treats with the space-time continuum directly: that today he dwells or will perish in the light of knowledge that is also power.

The same Graeco-Roman concept of forth-streaming is represented in the Vedic tradition of India by the *sristi,* the "throwing out" of the universe from the matrix of reality. In that tradition it is made clear that the process is governed by ideas, in which man shares, since he is primarily *manas,* mind. A universe is therefore called a *kalpa,* an imagining or carving out; in modern terms, the governed streaming of energy and life through the harmonic geometry which is slowly being revealed to us, especially in many aspects of physics and chemistry.

The drawing symbolizes the comprehensive sweep called for if modern scientific thought is to prove equal to its tasks. It may serve also to visualize the theme of the article by Professor von Bertalanffy in this issue.

EXPERIMENTS IN INTEGRATED EDUCATION:
Braziers Park School of Integrated Social Research

In Ipsden, Oxfordshire, England, about 55 miles from London, is located Braziers Park School of Integrative Social Research. This non-profit experimental school was established in 1950. Lecturers are guests of the school and give their services voluntarily.

The school aims are given as: "To learn all we can of human nature and its possible and desirable future development, and to publish findings which will contribute to the art of living and the science of life." The methods employed for this purpose are lectures and discussions, combined with opportunities for reflection and research, aesthetic and practical activities. The primary activities of the school are discussion week-ends on a wide range of subjects, also experiments in group research; experimental work in music, painting, dance and drama, handicrafts, etc. Holiday schools are held, lasting one or two weeks and dealing with various aspects of the science and art of social living.

We quote below, from the brochures put out by the school, excerpts which give something of the philosophy behind its work:

"We have reached the point in human history where man must take conscious control of his destiny if disaster is to be avoided. Mankind can be divided into those willing to experiment and so live dangerously, and those who are cautious and hesitate to leave the trodden path. These two groups are complementary and necessary to each other, but many of today's troubles are due to conflict between them. To restore to the world stability and sanity, these two groups must learn to cooperate.

"The philosophy that informs the School of Integrative Social Research has been much influenced by the writings of Wilfred Trotter, Sigmund Freud, Julian Huxley, Lancelot Whyte, and John Macmurray, and by the tradition of many religious thinkers and philosophers of the past. Those responsible for the direction of research in the early stages will expound and develop this philosophy; but since it includes the scientific principle of verification by reference to objective facts, it is ready to be transformed or displaced by any other approach to reality more closely in accord with the whole body of knowledge available for the use of mankind.

"Many of the problems of today have outgrown the capacity of the single mind of any one man, because they demand a sympathetic subjective understanding simultaneously with a ruthless objective appreciation of fact. But while the individual may find it impossible to give full conscious attention, logical and emotional, both to the self and to the not-self at the same time, it seems that in suitable conditions, a group of individuals will be able to enter into such internal relationships that a unitary group-mind capable of the dual function will eventually emerge. Its members can establish a relationship of mutual respect and confidence between two sub-groups, one of which gives first attention to the preservation and progress of the whole group, the other to the effectiveness of its service to humanity.

"This specialization of mental function is the basis of the resistive-sensitive or unitary method, and it will perhaps sufficiently explain why the School calls itself integrative.

"This philosophy, in its present form, includes recognition of a natural tendency in the human mind to get together with other human minds, and by specialization of function (resistive and sensitive) and division of labor to form a social organism whose abilities will certainly far transcend those of any existing single mind. It might be expected that this tendency would translate itself, without deliberate aid, into accomplished fact, were it not for other tendencies in human nature that seem destined to destroy the fabric of our cultural life long before the processes of nature can evolve such an organism by simple trial and error.

"But the processes of nature now include the prevision and creative thought of man; it is becoming clear that higher forms of life appearing on the Earth in future will be social forms, taking shape first in the imagination of man.

"The hope of resumed progress in the world lies in a deeper understanding of the possibilities of the individual, and of society functioning consciously as a benevolent environment for individuals; and in the centralization of all available experience, both rational and emotional, so that it may be made available anywhere in the world when it is needed to inform wise action. Given this, humanity can become organized on a basis of mutually helpful personal relationships, and economic considerations will take their proper place within this higher integrating process."

Lectures cover subjects normally included in degree courses on economics, biology, psychology, literature, philosophy, comparative religion, history, sociology, and anthropology, and a progressive liaison is planned with the courses of specialized instruction given in the Universities in all the subjects that are closely relevant to the integration of human life; the special contribution of Braziers Park is a technique for that integration.

Some of the topics for past lectures have been: "What is the nature of the phenomenon of consciousness and how far can it be used in integrative research?" "Do we need evil to fight?" "The three main ways of dealing with conflict: domination, compromise, and integration," "The technique of integrative social behavior," "The structure of religious experience."

QUANTUM THEORY

Robert B. Lindsay

Brown University

Some Recent Methodological Interpretations

Modern popularization has familiarized everyone with the names "quantum theory" and "quantum mechanics," and not a few have attained that blissful state of mind in which the terms appear to possess some meaning. Often this goes no further than a hazy comprehension that modern physics somehow requires discontinuities in energy flow in the case of atomic phenomena, and that this results ultimately in the abandonment of determinism in the description of atomic behavior. Though the quantum theory is now over half a century old, it is still surrounded by an aura of mystery for nearly all but the physicists and chemists who use it in their daily work. The reason for this is simple: It takes a very long time for a relatively new theoretical attitude toward natural phenomena to penetrate the collective consciousness of the race. We have but to recall that it was not until the late nineteenth century that the basic ideas and concepts of classical mechanics began to be really understood, though their origin by Galileo, Huyghens and Newton goes back to the seventeenth century. There is a significant methodological point involved here. The practical, and even what may be termed the scientific, application of a new theory may well antedate by a considerable interval a satisfactory philosophical understanding of the fundamental concepts of the theory. This is indeed aside from the problem of popular comprehension, though it is obviously not wholly disconnected from it.

It is the purpose of this note to comment on some recent methodological interpretations of quantum mechanics. The standard one accepted by most physicists is that usually referred to by the term "probability" or "indeterminism." On this view the state of an atomic system (or any microscopic collection of charged particles) is described by a certain function of the positions of the particles and the time. From this function in principle it is possible to calculate all observable properties of the system. If it is inquired just what the function itself really means, the reply is that the square of its absolute value is a measure of the *probability* that the system will be found in a certain part of space, and indeed from it one can calculate by straight-forward analysis the probable values of any observable parameter of the system (e.g. energy, momentum, etc.). The emphasis here is on *probability:* There is no way to calculate a measurable property of the system at any instant with absolute precision; one can only calculate probable values. Thus the theory is indeterministic, in contrast to the deterministic character of classical mechanics, which predicts the future of any physical system with complete precision from a knowledge of its state at any specified instant and the laws describing its allowed changes. It must, of course, be admitted that the measure of the indetermination of quantum mechanics is in general relatively small and does not affect the agreement of its results with experiment to a very high order of accuracy: This results from the relative smallness of the fundamental constant of Planck, the so-called quantum of action h (equal to 6.55×10^{-27} erg sec), which enters into all quantum mechanical calculations.

In principle, nevertheless, quantum mechanics is *indeterministic* according to the version accepted by most physicists, who indeed do not appear too greatly excited or concerned over this characteristic. It must be admitted that this is not true of everyone. In fact, some of the distinguished founders of the theory, notably De Broglie and Schrödinger, are dissatisfied with this methodological point of view and would like to see the theory rephrased in deterministic terms. A very interesting view of the current controversy has been presented by Henry Margenau in his recent Joseph Henry lecture before the Philosophical Society of Washington (*Physics Today, 7,* 6 October 1954). He contrasts very effectively the deterministic point of view (termed by him "mechanistic") with the standard and the current indeterministic interpretation (labeled by him "formalistic"). Finally he sets forth a view of his own different from both, though admittedly closer to the formalistic version than the mechanistic, since it involves assigning to probability an even more fundamentally real role in determining experience and leads to such consequences as denying that an atomic particle may have a position at every instant of time.

The names of Schrödinger and De Broglie have just been mentioned in connection with attempts to salvage a deterministic interpretation of quantum mechanics without changing its practical, workaday machinery. The interested reader will find their views

set forth in semi-popular or at any rate non-mathematical fashion in Schrödinger's article on "What is Matter" in *Scientific American* for September, 1953, p. 52, and in DeBroglie's survey of quantum theory, translated into English under the title, *The Revolution in Physics* (The Noonday Press, New York 1953, Chapter 10 and in particular Section 6 of this chapter). For the reader already conversant to a certain extent with the mathematical analysis of quantum mechanics, the articles by D. Bohm in the January 15, 1952 issue of the *Physical Review* may be recommended for careful examination. Bohm believes it is possible to devise a deterministic interpretation of quantum mechanics, which will reduce essentially to the ordinary formulation for phenomena taking place in space intervals greater than 10^{-13} cm (i.e., the dimensions of the atomic nucleus) and hence will agree with the usual results of the theory in the domain in which it has been spectacularly successful, but which may well differ considerably from the standard formulation inside the nucleus. It may be pointed out that it is just in nuclear physics that present-day quantum mechanics is encountering its most difficult problem, and one it has so far been unable to solve. There exists at least the hope that a return to the deterministic point of view may ultimately provide a quantum mechanical method capable of cracking the nuclear structure puzzle. Hence the considerations being presented here may turn out to have more than a methodological significance: It is conceivable that they will lead to a more powerful theory in the solution of actual problems of experimental nuclear physics.

We must be careful, indeed, not to conclude that there is any very strong trend back to the deterministic point of view in quantum mechanics. As a matter of fact one of the most recent commentaries on quantum theory methodology, that by A. Landé (Cf. *American Journal of Physics 20,* 353, 1952; *American Scientist 41,* 439, 1953; *Die Naturwissenschaften, 41,* 125, 1954) exhibits a tendency in quite the other direction. Landé has put forth the very interesting idea that one can develop the foundations of quantum mechanics by a rather subtle application of Leibniz' well known philosophical principle of the *continuity* of cause and effect (1687). This may be stated as follows: "A cause which increases *gradually* and *continuously* from zero always brings about an effect increasing *gradually* and *continuously* from zero and *never* an effect which increases *discontinuously* from zero to a finite amount." Thus if we increase continuously the resultant force on a body we do not expect to find that its acceleration changes discontinuously. The principle has been indeed tacitly accepted as a common-sense postulate in the mathematical development of classical physics, though by failing to keep it in mind certain philosophers have allowed rather careless reasoning to lead them to serious errors, notably Descartes in connection with some of his statements about the collision of bodies. (Leibniz came down on the celebrated Frenchman rather heavily for his mistakes in these problems.)

It appears at first sight strange that a principle of *continuity* like that of Leibniz can serve as a foundation for quantum mechanics with its discontinuous transitions between *discrete* stationary states of atoms. However, by examining the thermodynamic problem of the entropy change involved in the mixing of like and unlike gases, in which Willard Gibbs many years ago (1876) detected a peculiar paradox, Landé is able to demonstrate to his satisfaction that "*continuity* in the macroscopic thermodynamic domain requires *discontinuous* (i.e. quantum) transitions for particles." Moreover, these discontinuous transitions are governed by odds regulated by *probability*. The details of the argument are a trifle complicated, but need not detain us here. The important thing is that Landé believes he has knocked one more prop out from under the hopes of those physicists who feel that the probability interpretation may ultimately be supplemented by a deterministic one.

The claim is an ingenious and plausible one, but the present writer doubts that it will ultimately be found to be decisive. Landé's argument is based on the application of Leibniz' principle to thermodynamics. But the foundations of the latter subject, particularly in the case of phenomena involving *change* in systems (as contrasted to equilibrium thermodynamics) are still in the process of methodological examination. Hence one should not be too hasty in erecting an elaborate theoretical structure on the Gibbs paradox, and the problem of determinism versus indeterminism in quantum theory would appear to remain an open one. The writer sees no reason for changing his own feeling that in the description of the physical world the methodological foundations in the last analysis remain questions of taste. He is glad that this is so, for only in this way can we avoid the establishment of scientific dogmas, whose principal result might well be the stifling of the imagination of scientists. It is precisely the free use of the imagination plus careful observation which are the chief weapons at our disposal in the exploration of Nature.

What Is Heat?

In the September, 1954 issue of *Scientific American,* Dr. Freeman J. Dyson deals with the mathematical abstractions which rest on the notions of disorder and energy as he answers the question, "What Is Heat?"

"Heat is disordered energy. So with two words the nature of heat is explained. The rest of this article will be an attempt to explain the explanation."

The author points out that energy can exist without disorder and uses the examples of the kinetic energy of a flying bullet and the potential energy of an atom of uranium 235. When the bullet hits a steel plate, this energy is disordered and makes itself felt in the form of heat. The same kind of disordering transformation occurs with the fission of the atom. Dr. Dyson goes on to explain that the converse is true, that disorder can exist without energy, and that disorder becomes heat as soon as it is energized. He uses the example of the compressing of air with a bicycle pump. "The air has the same disorder it had before, but more energy. By doing work you have pushed more energy into the air, and the observed production of heat is just the effect of this addition of energy to the pre-existing disorder.

"In order to go further it is necessary to talk quantitatively. We must measure heat precisely in terms of numbers. Only when we have an exact language for describing quantities of heat can we formulate the physical laws that heat obeys."

There are at least two numbers required to specify heat: one to measure the quantity of energy, the other to measure the quantity of disorder. Energy is measured in terms of calories or, ultimately, ergs, and disorder is measured in terms of the mathematical concept called entropy. "With the help of quantum mechanics the definition of entropy can be given a meaning for any type of heat motion whatever."

Dr. Dyson goes on to explain how the numbers for the quantity of energy and the quantity of disorder describe the observable properties of heat. "Thermodynamics is based on two simple laws. The First Law is just the Law of Conservation of Energy: the total energy, including heat, of any closed system remains constant. The Second Law is a kind of law of 'conservation of disorder': the total entropy of any closed system must either remain constant or increase as time goes on—it can never decrease. The Second Law implies that heat must flow toward the region of lower temperature, for the following reasons. As we lower the temperature of anything, the amount of energy and disorder in it both get smaller. But the energy always decreases more rapidly than the disorder, so that the amount of disorder per unit of energy grows larger as the temperature falls. This is why heat always likes to move from a higher temperature to a lower; as it moves, each unit of heat energy acquires greater disorder."

The author explains that electromagnetic waves (light, infrared, radio waves, etc.) are a form of energy and that they are like other forms of energy, except that they can exist in empty space in the absence of matter. Like other forms of energy, disordered waves become heat. "So disordered electromagnetic energy is a form of heat which belongs to empty space, just as disordered motion of atoms is a form of heat which belongs to matter. All the laws of thermodynamics apply as well to the one kind of heat as to the other. Heat in empty space we call heat radiation.

"The existence of heat radiation implies that no material body is ever completely isolated. The space around every object will contain radiation; if there is a temperature difference between the object and the radiation, energy will move from the radiation into the object, or from the object into the radiation, so as to equalize the temperatures."

The characteristics of heat at extremely high temperatures are discussed. "Above 10 million degrees empty space behaves like a wet sponge, having an inexhaustible capacity for absorbing energy without greatly increasing in temperature."

—*Ruth Lofgren*

The Age of the Universe

The *British Journal for the Philosophy of Science* recently offered a prize of £50 for the best essay on *What is the logical and scientific status of the concept of the temporal origin and age of the Universe?* The essays judged the six best comprise the November 1954 issue of the journal.

The prize was divided between Mr. Michael Scriven of the University of Minnesota and Dr. J. T. Davies of King's College, London. Mr. Scriven's essay pointed out in particular how, if one means by "the Universe" *everything there is,* any question about the beginning of the Universe, Creation, and such gets one immediately into philosophical problems which are not to be resolved by choosing one current cosmological theory over another. The various theories of creation and estimates of age (by extrapolation of current rates of process backward in time) establish only lower bounds to the age of the universe but evade the ultimate question of whether or not the universe had a beginning in time. Most of the essays implicitly assume a kind of "absolute" time, that is, they assume the validity or meaningfulness of an indefinite extensibility into the past of our present sense of time-sequence, though some, like

Scriven, allow that time scales might have been quite different in different stages of evolution — for example, when the universe was in a highly condensed state. However, R. Schlegel and B. Abramenko adopt a more relativistic, and perhaps in a way a more humble point of view. Schlegel suggests a "temporal" universe, in which "it is only for limited sub-processes of the universe that time order, or past and future, may be defined;" the universe as a whole may show no consistent aperiodic, progressively changing process which fixes the direction of an "absolute" time. "Time is then only a 'local' property, as for example in the domain of our observations of galactic expansion and evolution, and questions about the extent in time of the total universe may not properly be asked . . ." Abramenko suggests a time dimension that is in some sense "curved," eventually back upon itself. "From the viewpoint of this hypothesis there is no point T_0 in the circle of finite time that might be called the temporal origin of the whole Universe." Any point on the circle could serve as an origin for individual formations, but the age of an individual formation would simply be equivalent to its "phase," or proportion of the total circumference. The circumference T would define the maximum age which it would be possible to discover for any formation in the Universe. Abramenko postulates T to be of the order of $21\text{x}10^9$ years.

The other writers, Davies, Opik, and Whitrow, adopt in the main a more limited and matter-of-fact approach, discussing the various scientific measurements and cosmological theories as they relate to the universe observable from earth. Evidence from red-shift in the light from distant galaxies, radioactive dating of minerals in the earth's crust and in meteorites, the dynamical stability of clusters and double stars, with some other general arguments, seem to converge to an epoch of the order of 4000 million years (of our present time scale) in the past as being fundamentally significant in our existence. The elements that make up our universe might have been formed at that time as the universe expanded from a state of tremendous density and tremendous temperature. But from the nature of the process postulated all traces of any previous history would be lost, so that we could never know whether that crucial epoch was an absolute Beginning, or merely the latest in a series of alternate compressions and expansions. One tendency is to leave the problem at this dead end, and content oneself with determining the apparent age of the oldest objects one can discover in the universe. Scriven goes a little further in that he considers the logical difficulties involved in any hypothetical observer being able to decide the precise instant when the first something begins to exist, and questions the meaningfulness of the concept of *time* without *things*. He is led to conclude "it is a tautology to say that however far into the past we delve, we shall always find evidence of an existent state." Thus his conclusion is: "no verifiable claim can be made either that the Universe has a finite age or that it has not. We may still believe that there is a difference between these claims; but the difference is one that is not within the power of science to determine, nor will it ever be."

Besides the discussion of philosophical problems, the essays serve as a useful review of the state of cosmological knowledge up to the contest deadline, December 1, 1953.

—*Ray Jackson*

Conflict and Integration

The resolution of conflict by a process of "integration" is proposed by Dr. D. K. Adams of Duke University in "Conflict and Integration" in the *Journal of Personality,* 1954, vol. 22, pp. 548-556.

"One of the variables of personality that is much referred to in psychological theory, but rarely clearly described in general terms, is integration. Nearly every current conception of personality makes use of the notion and usually, I suppose, with a meaning something like "freedom from conflict." But how this state of affairs comes about and how the concept of integration is to be integrated with the other concepts required by psychological theory are generally left obscure . . .

"To understand the *process* of integration, we have to look at the process of personality development. An analogy with bodily development will compress the exposition. Organic growth is a process of differentiation from a single cell, itself highly structured and integrated. In the process of differentiation this integration is maintained by the dominance of regions of high metabolism over regions of lower metabolism, these regions themselves often determined by environmental circumstance in the earliest stages . . .

"The infant personality is also slightly differentiated and highly integrated." Dr. Adams continues to describe the gradual differentiation of object-relationships within the personality of the child. At first he has a few simple desires or needs. The integration of the infant is disclosed in his complete involvement in whatever he is doing. Conflict in the child arises from one source — frustration. It is only later that the child is capable of conflict "in the sense of simultaneously wanting incompatible things . . . This may be due largely to the relative absence of a future in the young infant, or what some call the absence of a time perspective." The degree of differentiation that takes place in a child's personality in regard to object-relationships depends upon several things, but the most important variables, according to the author, are the number of objects available in the environment, and the amount of freedom and love which the child has. "Even an environment objectively rich in objects may fail to evoke maximum differentiation if the child's commerce with them is limited by the impersonality of the regime, while one objectively poorer in objects but permeated by an atmosphere of love, will evoke maximum commerce with such objects."

Although most discussions of conflict emphasize the conflicts which arise from personal desires and the values of the culture, Dr. Adams points out that other types of conflict are also important. A child may want to pet a puppy, but at the same time be afraid of it. A person may want to go to a circus and also a ball game which takes place at the same time. One is mutually exclusive of the other in this latter example. If the person goes to the ball game he may still have an unsatisfied appetite for the circus. In this case we would say that "conflict resolution" has not taken place. As long as conflict resolution does not take place, we may have a high degree of differentiation, but a lack of integration of the personality.

Dr. Adams proposed that if the person in such a conflict, between going to the circus or the ball game, will reevaluate the situation and realize that either act is a means to the same goal, then the conflict will be resolved. "Thus our boy may perceive for the first time that ball game and circus are both means to recreation in general and that this long-term goal will be better served by going to the circus which comes but once a year or by playing ball, in which case the money saved can be applied upon a bicycle. In either case the alternative will have been set in a larger context and the conflicting sentiments *integrated* into one . . .

"Every time a conflict is resolved in the way described, a step in the integration of the personality is accomplished; and this may proceed to the complex but orderly and hierarchical subordination of all values, all objects, to one."

—*W. M. Nicholson*

Cultural Values of Science

The relationships between science in general, engineering in particular, and the culture of which they are intrinsic parts, are considered in "Chemistry, Chemical Engineering and Culture," by Harold G. Cassidy, which appears in the *Journal of Chemical Education* (February, 1955, pp. 86-88). The paper was first presented as part of a symposium on the Cultural Values of Chemistry, at the 126th Meeting of the American Chemical Society, New York, September, 1954.

As basis for his discussion, the author takes Ortega's definition of culture "the characteristic attainments of a people or social order," and further identifies these attainments as "the ideas by which we live — the abstract ideas that are powerful forces in our society," some of which have been our heritage, and some of which are being contributed today. The problems of science and technology are considered in relationship to the whole of culture, and also specifically from the point of view of college and university education, since it is the educational system which transmits our culture to young people.

Scientists and engineers have as much right as anyone else to define, analyze and criticize our culture, Dr. Cassidy considers, and he points out that since no one can do or learn everything, all must specialize, and through their specialization they contribute directly to our culture. However, the inevitability of such specialization for vocational training in the universities should not make us lose sight of the fact that our culture is not specialized, although it has many aspects which may be classified as humanistic or scientific.

"The whole domain of knowledge and experience is a continuum, with divisions in it made only because of necessity imposed by human limitations and the pressure of inelastic time . . . Our culture consists of the ideas which vitalize these disciplines—which vitalize the field of knowledge and experience. Our culture is indisputably *both* scientific and humanistic. Moreover, all parts contribute to and complete the whole. People in all disciplines have the right to claim their insights about the whole. They also carry, as justification for this right, the responsibility to try to see that they themselves are not the whole . . .

Dr. Cassidy makes the point that the engineer and other professional technologists, including the lawyer and physician, are in an unusually strategic position to mediate between the humanities and the sciences. The engineer takes general laws and makes application of them to individual work, which may also embody the humanistic qualities of aesthetic value and ethical judgment.

It is in the area of creative activity that Dr. Cassidy sees a close relationship between the scientist and the humanist: "a common basis and common purposes—the basis, a common heritage; the purposes, those of the pursuit of knowledge and experience." In all creative work there is experiment, testing, rejecting, judging—and the same human feelings of joy in creation—whether it be in the development of an architectural form, a musical composition, or a chemical experiment.

The cultured person is defined by the author as "one who comprehends the great ideas of his time in perspective against those of the past; one who understands the power of ideas and has made out of this knowledge the choices that guide his behavior . . . Today he must understand rather deeply what science tries to do and he must be aware, at least in a general way, of the strengths and weaknesses of science. He must also know the distinguishing characteristics of the humanistic approaches to knowledge and experience and their strengths and weaknesses. He will be a specialist in one area of the sciences or humanities, but his claim to being cultured will be strengthened in proportion to his success in the creative combination of his knowledge of the two areas." Dr. Cassidy feels that the humanist approaches this ideal less closely than the scientist, for many scientists pursue actively their interest in some aspect of music, art or

literature, but few humanistic specialists pursue science. This is in part a problem of language and as such the scientists should help to remove it, thus making scientific insights more available and more attractive. Dr. Cassidy points out that the sense of "crisis in the university" is greater among humanists than among scientists, and that an increased sense of participation in science by humanists would help to alleviate this, and bring about a greater feeling of unity.

—*E. B. Sellon*

Prof. L. L. Whyte makes a plea for more attention to dimensionless quantities and formulations in physics, in the *British Journal for the Philosophy of Science,* May 1954. He asserts that in certain respects physical laws expressed in forms containing dimensional quantities (e. g., quantities measured in feet, grams, seconds, etc.) are incomplete, misleading, and over-complex.

"They are incomplete, because they do not show how the variables are to be measured, the theory of measurement being treated independently . . ." For example, the assertion "the universe is expanding" is incomplete; no standard is specified. "Cosmologists do not appear to have agreed whether this means, for example, relative to a rigid rod, an optical wavelength, an electronic length, or the cube root of the volume of a standard extragalactic nebula. The choice should be determined by the character of the observations that have been made, and is important because the theoretical interpretation to be given to the phenomenon will be different in each of the four cases. Only a dimensionless formulation can eliminate this ambiguity, and only a dimensionless calculus can ensure correct treatment, just as an invariant calculus (in relation to co-ordinate transformations) was necessary to ensure conformity to the principle of relativity."

Dimensional laws are misleading because they do not reveal explicitly the limits of the ranges of the variables within which the expressions are valid. For example, the classical Coulomb law does not reveal that it is not valid at very small distances comparable with e^2/mc^2. Proper formulations ". . . would emphasize unmistakably the fact that the established dimensional laws must be viewed as asymptotically valid Limit Laws of some unknown General Law. . . .

"Finally laws involving dimensional constants *contain a redundant element,* for, as Whitehead observed, the presence of a dimensional constant implies that a possible definition of congruence has been omitted . . . the multiplicity of dimensional constants arises partly because physical theory has neglected certain latent congruences or (e.g.) ways of deriving time-measures from space-measures (or vice versa)."

Prof. Whyte recommends that instead of, for example, regarding idealized isolated particles as primary and the general phenomena as "interactions" of these particles, we should proceed more the other way about, regarding the particles as special "limiting aspects" of the general process. In this he is, of course, operating from a Whiteheadian conceptual base, wherein such theoretical constructs as elementary particles are regarded as "high abstractions from nature," as opposed to what might be termed the Kantian conceptual base, or metaphysical belief, that such constructs are "insights into the reality behind phenomena." It is particularly interesting to hear what in many respects resembles an "operationalist" critique, being voiced from a Whitehead frame of reference.

—*Ray Jackson*

One avenue of attack on the mathematical representation of social processes is described by M. M. Flood in a short review paper in *Transactions of the New York Academy of Sciences,* February, 1954. The object of his work has been "to construct a mathematical model for the human social interaction process," and his paper is titled "A Stochastic Model for Social Interaction."

He sketches the logical features of an elementary mechanistic analogue to simulate some rudimentary features of the "learning" behavior of a socially-interacting entity. As an example, he discusses the features of an entity having three possible responses to stimuli. The relative probabilities of the possible responses are modified by past results in the form of reward or non-reward. The system can be generalized to allow for n possible responses, with m different forms or degrees of "reward" or "stimulus." A machine, built with these features, or a computer programmed in this way, would be called a SAM-mn. Flood discusses a SAM-29 and compares its probable response after, say, 100 "learning experiences," with the analogues probable (statistically observed) response of a human subject after the same number of rewarded and non-rewarded choices. He cites some experimental results of a preliminary nature.

—*Ray W. Jackson*

Two researchers at the University of Tasmania have evolved a technique for measuring the electric fields around growing plants which they claim is less susceptible than other methods to errors introduced by the electrodes. They grow the plants in a weakly conducting fluid medium and study the currents generated by the plants in the medium by means of probes placed in the medium near the plant. Their results show a clear difference in the change of potentials with time between the case of a rapidly growing bean root and the case of a bean root of which the growth is inhibited. They observe oscillatory patters characteristic of the bean root when it is changing its direction of growth, spontaneously or to avoid an obstacle. The experiments are part of a general study of patterns of morphogenesis, of which the authors hope to publish more in the future. (A. L. McAulay, B. I. H. Scott, *Nature 174*, p. 924, Nov. 13, 1954).

—*Ray Jackson*

NEWS AND NOTES

Readers of MAIN CURRENTS will be kept in touch with the progress of the new Society for General System Theory, announced below, as they have been with other frontier studies, such as those in social physics, by John Q. Stuart, Stuart Dodd and others, in altruistic techniques, by P. A. Sorokin and his colleagues, and in new evaluations of comparative cultures represented by Bollingen Foundation publications, among others. If only looking to the future of the new Society, more than one reading of Professor von Bertalanffy's article may be prudent. Something more than science and formal philosophy is involved.

For the eventual development of a General System Theory good in all natural realms—those of matter and energy, of life and functional form, of man and his works—bears upon an ancient, recurrent question posed more urgently in recent decades: how is the rational mind of man related to the regularities of nature? There may be those who would have us believe that no part of human reason is identical with the structural basis of natural things, and that theory is only a temporary scaffolding upon which one mounts to inspect some particular, superficial parts of the edifice called the universe.

Without doubt hypothetical structures, such as stochastic or conjectural models, are useful in early stages of scientific inquiry. But temporary abstractions which clump together a collection of data do not bear the same significance as do freely postulated and empirically tested logico-mathematical formulations, such as are employed in relativity and in quantum theory. The work of Albert Einstein makes the distinction clear, and renders untenable the position of those who arrest their thought at the level of hypothesis. Making masterly use of developments throughout physics, especially since 1900, he has, as all know, given status to the idea that any consistent and exhaustive body of mathematical doctrine, though apparently a free invention, is likely to prove fact to be a model of some aspect of reality. Except for its postulates it is not, of course, a free invention; and the postulates, whence come they?

It is true that we are not always able to determine at once where in nature the finished model operates, as, for example, Riemann's geometry has been applied to, or disclosed in, the workings of the macrocosm. That very useful geometry went begging for a long time until it could be applied to nature. A current instance is the use of the cube-octahedral net of Euclidean geometry in crystallography, while the rest of the group theory of which that net is a part has had no comparable empirical applications. It may well be that such applications will be found not in physics, but in biology. (See MAIN CURRENTS, Vol. 8, No. 1, p. 9.) At any rate, throughout the 20th century the proposition that reason is an ingredient of reality has had sufficiently numerous and authoritative empirical tests to give it general respect.

Developments in General System Theory, since they are to be derived from all departments of nature, thus promise to be helpful in establishing more firmly our knowledge of the true nature of man, as a mind, and to enrich greatly our knowledge of the vast stretch of ground common to human reason and to the principles of natural order. In these times, when anti-intellectualism is a serious threat, every gain which puts *ratio* in its proper place between *scientia* and *sapientia* is especially important. We welcome the new Society with particular satisfaction.

—*F. L. Kunz*

A Society for the Advancement of General System Theory is in the process of organization under Section L of the American Association for the Advancement of Science. The founding committee consists of Ludwig von Bertalanffy (biology), K. E. Boulding (economics), Ralph W. Gerard (physiology), and Anatol Rapoport (mathematics), all at present at the Center for Advanced Study in the Behavioral Sciences at Stanford, California. The Statement of Purpose of the Society reads:

"The main purpose of the proposed Society for the Advancement of General System Theory will be to encourage the development of theoretical systems which are applicable to more than one of the traditional departments of knowledge. All sciences develop theoretical systems of concepts, relationships, and models. Many of these systems are isomorphic, but their similarity is undetected because of differences in terminology and of other barriers to communication among specialists. Furthermore, systems which have been well worked out in one field may be helpful in another.

"The principal aims of General System Theory are, therefore:

1. To investigate the isomorphy of concepts, laws, and models in various fields, and to help in useful transfers from one field to another;
2. To encourage the development of adequate theoretical models in areas which lack them;
3. To eliminate the duplication of theoretical efforts in different fields;
4. To promote the unity of science through improving the communication between specialists."

An organizing meeting was held at the convention of the American Association for the Advancement of Science in Berkeley, December 27, 1954. Professors Bertalanffy and Boulding presented the aims of the Society. The modern development of the biological, behavioral, and social sciences necessitates an expansion of our conceptual schemes. There exist theoretical models, principles and laws of generalized "systems" which are applicable in different fields. A main problem of modern science, further, is a general theory of organization. Concepts like those of wholeness, directiveness, teleology, and the like, although alien to classical physics, cannot be avoided when dealing with biological, behavioral, and social phenomena. There are various trends in modern science dealing with the problems mentioned, such as General System Theory in the narrower sense, the theory of information, of games, of decision making, etc. The proposed Society has as its main goal the further development of such theory, and correlation of the various approaches.

Among the further plans of the Society are the presentation of annual volumes of articles in the area of General System Theory, to be selected and printed from the increasing but very scattered literature in this field; the organization of a local group and conferences on the West Coast; and the arrangement of general meetings in connection with the AAAS. A donation from the K. Bostrom Foundation facilitates the organizational work. Enquiries should be directed to Dr. L. von Bertalanffy, 202 Junipero Serra Blvd., Stanford, California.

While our experience in the development of integrative methods for teaching progresses slowly through the participation of members of our staff in experimental courses, we are making an effort not only to accumulate but to evaluate and comment upon materials regarding the needs and methods of education.

These materials are not ready for distribution in published form and many of them have not yet been tested in actual classroom use, but we would welcome criticism and testing of them by teachers. Only in this way can the practical applications of integrative methodology be developed for use at all levels of education.

In the last issue of MAIN CURRENTS notice was given of the publication of the report entitled *The Schools We Need — Now and For Tomorrow* by the N. Y. State Regents Council on the Readjustment of High School Education. As we indicated in this first comment, this is an excellent and timely study and one which should have wide-spread practical results. We have since studied the Council's appraisal of needs and their recommendations, and have applied this Foundation's philosophy and methodology to them point by point. Many of the recommendations appear to us to be opportunities for the direct application of integrative techniques.

In the Nov.-Dec. 1954 issue of *Chicago Schools Journal,* we noticed a paper by L. J. Caldwell, Supt. of Schools of Hammond, Indiana, entitled "Scientific and Professional Manpower Needs." This paper analyzed the decline in enrollment in science courses in our high schools and colleges and discussed means of reversing the trend. To us it appears to be significant that science as a specialty is losing out at the very time when one would be led to suppose that science and technology were dominating the educational scene. It becomes apparent from this paper that one of the causes of a growing unpopularity of the sciences may be that science has been presented to students as some sort of an esoteric cult of great difficulty. If this be a proper appraisal, it would seem that science lacks volunteers because its over-specialization is "backfiring" upon it.

The thesis of this Foundation has been that science is a cultural mode and should be taught to everyone as such. Whereas the author of the paper here discussed proposes ways and means for the recruitment of science majors and science teachers, it would seem to us that a better way of keeping up with our "scientific and professional manpower needs" would be through an integrated curriculum in which every pupil is introduced to science as but one mode whereby the human mind contacts reality. Having been introduced to science in this way (rather than by the usual means which might be called "science is something difficult and special"), more students can be expected to gain insight into the true spirit and method of science and so might volunteer for service. It would seem almost as if we had reached the jumping off point of over-specialization if we must "sell" science courses to future scientists while leaving laymen in the darkness of illiteracy and blind faith in something which is too difficult for them to understand. This is not the entire burden of Mr. Caldwell's paper; but this one point does provide an opportunity for us to evaluate our philosophy and methods against actual trends in education.

While we are reviewing published materials and our analysis of them, mention should be made of two papers by Gilbert E. Doan (Manager of Metallurgical Research, Koppers Company, Inc., and formerly Head of the Dept. of Metallurgical Engineering of Lehigh University) which appeared in the Nov. 1952 and Jan. 1955 issues of *Mechanical Engineering.*

These two papers were entitled, respectively, "Stronger Engineering Graduates" and "The New Position of Science." The first was an appeal for a revision of engineering education which would ". . . turn out consciously integrated graduates dedicated to a life of justice, reason, mercy, and truth . . . This integration should be the culminating phase of a man's education. It is the creative answer to subversion of all kinds." The second is a splendid essay on the thesis that "the basic tenets of science which have prevailed for the past century are undergoing drastic re-examination. Today the new philosophy is

'humble and stammering, where the old philosophy was proud and dictatorial.' Immutability of the laws of science no longer governs the approach to research, but rather one of reliance on faith. The hope of Western civilization lies in its faith in science and with it faith in the principles of truth and justice which are the 'miracles of democracy.' "

We have had pleasure and stimulation in matching this Foundation's philosophy and methodology with these papers, and find a powerful ally and exponent of integrated education in Dr. Doan. For example, we wish we had said (as Dr. Doan says): ". . . America is still wedded to faith. This union, joined in Washington's and Jefferson's day, has born the marvelous fruit these leaders anticipated. We ought to acknowledge our faith with pride; teach it openly and *make no exception for science*. . . . If this integration is achieved, then the university again can become the backbone of our civilization. Science will contribute richly to truth without in the least discrediting the other major areas of faith. On this basis the whole of western civilization can again go forward."

—*Harvey W. Culp*

The Editors of MAIN CURRENTS report with great regret the death of one of its valued contributors, Dr. William E. Galt of the Lifwynn Foundation for Laboratory Research in Analytic and Social Psychiatry.

Dr. Galt has been a Source Reader for us since 1953. His perception of the need for greater integration in the physical and social sciences, and his broad understanding of psychology, sociology and related fields have caused him to bring forward for our readers' attention many items of philosophical importance. His loss will be deeply felt by the Lifwynn Foundation, as it is by us.

REVIEWS

Ideas for the Future and for Now

Crown Publishers, Inc., have provided the layman who is an industrious amateur, and not a vain dilettante, with a volume of unsurpassed value, *Ideas and Opinions*, by Albert Einstein (New York, 1954, 371 pages, $4, no index). The papers selected are from *Mein Weltbild* and other sources so scattered as to be hitherto nearly inaccessible. The translation and revisions are done with a masterly command of the idiom by Sonja Bargmann, aided not only by Einstein himself but also by Valentine Bargmann, Professor of Mathematical Physics, Princeton University, who also records (pages 217-220) the sequence of chief events in Einstein's development of physical theory.

About half of the volume is devoted to trenchant and even-humoured, but sometimes biting, observations about social, educational, and political affairs, including addresses in celebration of great personalities and arguments for peace, and about the Jewish people, and Germany. In those passages the reader will find evidence of the writer's humanity, and that integrity of feeling and action and thought which are clear signs of spiritual power. He will also find there, for example, "Remarks on Bertrand Russell's Theory of Knowledge," six pages in which Russell's gifts, and also the haunting fear he has of metaphysics, are looked at by Einstein from above in a fashion for which many of us lowly folks (who have only been able to feel from our inferior position below an uneasy doubt about Russell as a philosopher) will be ever so grateful.

It is, however, the final third of the volume which will be read to bits, we predict, by hungry-minded students and conscientious teachers who have little or no higher mathematics, little or no formal logic, little or no other technical resources for philosophy, but who do not mind hard thinking, and long to know in Einstein's own words whatever they can of the events which took place at the highest level in physics from 1900 to 1945.

The value of this presentation is that we see the master of the whole enterprise coming at several aspects of the complex first from one approach, then another. Each time he starts from some point which nearly any literate person can appreciate, and moves in with that certainty of command which takes the reader along. The economy of thought is incomparable. Even if one does not at first reading get it all, he can greatly enjoy the finesse. But in fact, in the end, no doubt clumsily, yet measurably, the layman can go a long way into topics like motion, fields, the abandonment of fixed reference frames, the place of the quantized microcosm, the continuum, and the theory of relativity both special and general, starting always from a territory not altogether so foreign as to frighten him off. Even if he goes not quite to the end at first try, no matter, for with patience he feels he will get what he needs.

Teachers who want their students to appreciate natural laws — upon which, through the Constitution, this country rests its freedom for every citizen — and how such law is known, and what such knowing means about the nature of man, must reckon with Einstein, Planck, Schrödinger and the rest of the defenders of the faith. Such teachers, in totality, necessarily must behave with one another more or less like laymen. For such a group is scarcely likely to include even one man

competent in classical language and literature, mathematics, physics, biology, psychology, sociology, oriental thought, and the rest of the present dizzying complex. Now it happens that Einstein and his peers are working at a level where these differentia tend to grow unimportant. Einstein himself may not even consciously be aware that what he says herein identifies his position as to the nature of human mind (for example) with that of the *Bhagavad Gita*. Yet it is so. He is saying (in effect) not that mind is merely brain. We can have no idea, from this book, what he thinks about that. He broaches something much more subtle. By calling geometric axioms definitions, and then asserting the invariable connection of consistent exhaustive geometric theory with the behavior of matter and energy, he has in truth thereby declared that mind is not a mere agent of the irresponsible, the unnatural, the *a priori*, but is itself thereby proved to be in some manner or other material in character, but in its own generalized character.

Now this is precisely the position in the Sankhya philosophy, which the *Gita* makes its starting point. Therein *manas* (mind, a term cognate with the English word man) is declared to be a modification of energy, or *prakriti*.

The time is not yet, but it will come, when the insight of the Vedic Indians and of the pre-Aristotelian Greeks will be seen to be essentially the insight into the same universe and the same Reality which the modern physicists are actually proving to exist, and to control us and evolution. Here and there already a few distinguished individuals are beginning to see or to sense this possibility of arriving at a deep-level unification of culture, with new authority: Toynbee, Margenau, Oppenheimer, Northrop.

We do not expect contemporary teachers of general education to be able to care much about all of this. They are burdened with innumerable problems, by no means all of their making. But we look to the future. In that future there will be many in East and West, in science and in religion, who will be grateful to Albert Einstein and his colleagues for beginning the work which is to unite the world in constructive philosophy and realistic knowledge, as firmly and as well as the politicos seem bent on destroying its unity, by using the physical by-products of that philosophy to keep us in turmoil and a state of terror. Some will be grateful even now, on these higher grounds, to the author, the translators and the publishers of this admirable book.

—*F. L. Kunz*

A Philosophy of Life and a Philosophy of Education

Dr. Robert Ulich has given us in his new book, *The Human Career* (Harper & Bros., N. Y., 1955, 247 pp., index, $3.50), a magnum opus which is destined, we are sure, to be influential in philosophy and education for many years to come. Subtitled "A Philosophy of Self-Transcendence," this well-written volume not only affords the reader a philosophy of life and a philosophy of education but it also gives a lift to the spirit as one reads and reflects upon it.

We shall not here presume to make a step-by-step review or criticism of the book. But we must point out that, in our opinion, Dr. Ulich expertly synthesizes the best in the modern sciences of man to demonstrate that man is a self-transcending being: ". . . he represents a product of the creation which, though deeply grounded in its physical base, has risen above the vegetative level to the heights of reflection and self-reflection. The world in which man stands is at the same time the world which he comprehends by virtue of intellect and of reason. The degree of this comprehension constitutes at the same time the degree of his freedom. . . . The widening orbits of man's experience lead him to the insight that his environments are of both a physical and a spiritual quality. In order to achieve the fullest degree of maturity, he should pass beyond ever-enlarging social organizations toward a qualitative concept of humanity — humanity as being not the totality of human beings, but the brotherhood of men conscious of their common ground in the creation. Also, here 'world' in its fullest concept arches in its grandeur above the small 'worlds' around us. . . . He knows of himself and his being in the world, and the more deeply he goes into himself, the more embracing becomes the knowledge of the cosmos in which he participates. . . . Only when with the expansion of his reason his power of faith grows, can he rest from time to time in himself and the world and receive the inspiration which he needs in his struggle for a final meaning of human existence and history."

We recommend close reading of pages 100 to 113, inclusive, for the author's discussion of "The Meaning of Thinking." These pages should provide teachers with some fresh insights into the problems of "student motivation" just as the chapter immediately preceding this quotation should help to "motivate" both student and teacher: ". . . learning represents the highest and freeest form of the participation of the self, in a world whose endless growth weaves its various elements into a unified whole. Learning is possible only because there is a mutually sympathetic universe with a harmonious interrelationship between the I and the objects intended in the learning process . . ." and again, "There is no other way for mortal man but to search boldly for all that is and may ever be within the limits of the explorable, for only in this way may he reduce the territory of darkness. The inexplorable and unachievable of today may be tomorrow's scene of victory. But there will ever be cause for man to bow in humility. For the great Unknowable will always stand before him in silent majesty, exciting his endless curiosity, yet unconquerable."

A reviewer is at a loss as to how best to point out the important and beautiful landmarks in a book as rich as this, but we cannot let it suffice merely to mention that the author presents an excellent chapter on "Ethics as Practical Self-Transcendence." We must indicate its poignant significance for our times by quoting the final sentences of this chapter: ". . . man lives with values just as he lives with men and things. When people in a specific period are no longer able to feel the urge of the good, however they may interpret it—when the search for the depth of reality is lost to them, then it is the time of their decay. . . . Only by an inner world can the outer world be mastered." In like manner we must point out that, in considering "The Dilemma of Human Organization," the author points to Russia where "... a genuinely pious people accepted a new ideology not

only because there was force, but also because there was a promise of unity between life and hope which had been lost in the old system." In concluding this chapter, the author reminds us that "...men will never emerge from the shades of darkness until both the spiritual orbit (which we may call 'Church') and the temporal orbit (which we may call 'The State') join in the attempt to unite human existence under the universal laws of life."

To those whose concern is religion there is a fine chapter here which may not exactly please the orthodox but which it is very important that they read and meditate upon; to those whose interest is in art a new importance to this mode of life can be gained by a chapter devoted to art which is a work of art itself. To those who are concerned with education this entire book is a must, but they should morally be denied continuance on tenure if they neglect to study Dr. Ulich's tenth chapter. Here, again, the orthodox may be irritated and those who engage in heated debate may feel that the discussion is "too philosophical." But we who believe that integrated education should be education in depth, are forced to cheer when the author says, "An education, therefore, which believes it thrives better without deeper metaphysical interest may produce a materially informed and busy society, but it will be one without depth. Sooner or later even its efficiency will run dry for lack of inspiration. It may be remembered for its quantity, but not for its quality."

We wish to thank both author and publisher for giving us this book at this time. What we have needed has been a *Psychology of Self-Realization* (by A. Maslow), to be sure. But next to this on any shelf should go this *Philosophy of Self-Transcendence.* Without the latter, the former, however good, may lead us astray for, as Dr. Ulich warns us in his concluding sentences: " . . . No religious prayer, however deeply felt, will help us if our knowledge increasingly alienates us from life rather than serving as a means of universal kinship. And no knowledge, however intensive, will avail us if we allow our lives to be darkened and misdirected by magical concepts even if they come in the name of religion. What we need is the unity of religion and rationality: 'rational piety', if you will, or 'devout reasonableness.'

"This was the attitude of the founders of this republic. This attitude alone, because capable of ever new development, can save us in the future. In it alone lies the hope for progress—slow, arduous, short of final achievement, but nevertheless full of hope, joy, and unending vision."

—*Harvey W. Culp*

Human Dynamics

We recommend a small volume entitled ***Human Dynamics and Human Relations Education*** by H. Harry Giles (New York University Press, N. Y., 1954, 99 pp., Bibliog., $1.25). The author states in his opening paragraphs that "It is possible that we now have, if we could but put it in usable form, a large part of the knowledge needed to manage human affairs for purposes of good, for a fuller life for all, rather than for purposes of evil . . ." A little further on, he remarks that the reasons for the slow development of this new knowledge have been that ". . . scientists have not . . . talked a language which could be commonly understood [and] the initiates of one discipline have not talked to those in other disciplines . . ." The first chapter of this volume attempts to present "An Integrative Theory" of human dynamics ". . . as an attempt to simplify, make coherent, and describe such knowledge and insight as is now at hand."

The book progresses through a presentation of "Growth — An Examination of Concepts from the Biological and Psychological Sciences" and of "The Individual — Limitations and Potentialities for Growth," to a consideration of "Growth and Human Society." These three sections are summed up as follows: ". . . It seems clear that human purpose can be the dominant factor in directing human evolution, and that its dominance (over chance, over environmental conditions, over cultural constructs) is in direct proportion to the clarity with which the purpose is seen and to the extent to which all share in its creation, and therefore its acceptance."

Quite naturally, the statement just quoted leads to an excellent chapter on "Growth, Democracy, and Education." Here are to be found many excellent references from our founding documents and those who have guided and preserved the democratic way of life. And a clear case is made for those who would like to use this volume as a brief text or source book for the explanation or the advancement of democratic ideology.

For students of human relations—whether in the home, the community, in organizations, or any other phase of interpersonal relationships—will find in the final four pages an excellent summary of the dynamic principles of human growth and development. Certainly, everyone whose work involves dealing with people can profit from this outline.

—*Harvey W. Culp*

"The powers of the person are what education wishes to perfect. To aim at anything less is to belittle men; to fasten somewhere on their exterior a crank which accident or tyrants can twist to set machinery going. The person is not machinery which others can run. His mind has its own laws, which are the laws of thought itself . . . A liberal education is more than a classical education, more than an education in English literature, more than an education in what is called 'the humanities,' and more than a training in the moral virtues . . . If science is master of the intellectual arts proper to the conduct of its affairs, then science is liberal too.

"A democracy that is interested in its future will give each of its members as much liberal education as he can take, nor will it let him elect to miss that much because he is in a hurry to become something less than a man. It is obvious that all cannot be philosopher-kings, but it is just as obvious that all must not be less than they are; and a democracy must be prepared to give the entire quantity of itself that can be taken . . . [The citizen] can never blame a society which encouraged him to be all that he could be."

—From *Liberal Education,* by Mark Van Doren, quoted by Carroll V. Newsom, Associate Commissioner for Higher Education, University of the State of New York in his Summation at the conclusion of the Thorne Lectures presented at Hofstra College. ***What Should Higher Education Be Doing in 1954?,*** Myron H. Luke, ed., Hofstra College, Hempstead, N. Y., 1954, p. 61.